# WILLIAM O. BAKER'S ODYSSEY

## *Former Bell Laboratories chairman has played central roles in national science, technology, and security policies*

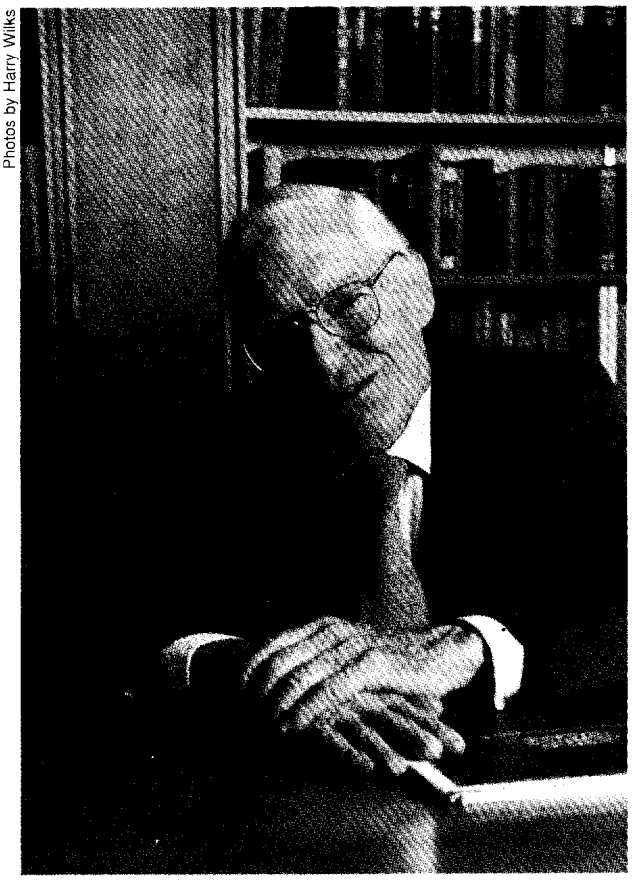
*The U.S. government has recently declassified information on one of the most closely held secrets of the Cold War: breaking into the Soviet Union's highly encrypted ballistic missile command-and-control system. It turns out that one head of that hugely complex decryption effort of the 1950s—President Eisenhower's Ad Hoc Task Force for Application of Communications Analysis for National Security—was chemist William O. Baker, 81, former chairman of AT&T's Bell Laboratories.*

*Baker's central role in advising presidents from Truman to Bush on crucial national security matters and science and technology issues is already widely known. But Baker has never been interviewed at length on his experiences during the Cold War and beyond and has never before discussed his role in breaking the Soviet security code. In this interview with C&EN Senior Correspondent Wil Lepkowski held at Rockefeller University in New York City, Baker discusses those matters and ranges across several other issues of science, technology, and national security.*

*Baker received a Ph.D. degree from Princeton University in 1938. His thesis work involved the dielectric properties of organic crystals. Baker decided early on that he wanted to work in the science and technology of communications, which meant considerable mastery of mathematics and more than a working understanding of quantum mechanics in order to meet the solid-state demands of his field. He began work at Bell Labs in 1939, and early in his career he played a key role in World War II's synthetic rubber program. Since his retirement from Bell Labs in 1980, Baker has maintained an advisory role there. He serves on the boards of various corporations and foundations while working at improving the science, technology, and educational climate of New Jersey, specifically, as well as that of the nation as a whole.*

*Baker's conversational style is rarely to use the word "I." He usually speaks of "we" or "us," and this published interview will remain largely faithful to his style, whatever modest ambiguities it might cause the reader.*

Photos by Harry Wilks



***Some chemists might wonder how you, a chemist, became so heavily involved in matters of national security.***

Well, science and particularly chemistry have always been highly relevant to meeting the needs of national defense and national security. My own career involved applying chemistry and materials science to the needs of telecommunications. And telecommunications are the essence of modern military and security needs, which, of course, contributed to national strength and helped equilibrium among nations.

My involvement in telecommunications led to my various assignments from President Eisenhower and his successors in improving the country's capabilities in communications and command and control. These involved some of the most challenging problems in software, facilities, and machines which resulted in protection of the United States as well as access to the command-and-control activities of possible adversaries.

The most compelling aspect of all this was the command, control, military, and strategic communication systems of the Soviets. It was an exercise that was assigned in the White House and involved many of the very capable American security agencies, especially the National Security Agency. It put high demands on the kind of capability that modern chemistry, and science and technology in general, have.

***With current declassification of material from the Cold War era, it has come to light that you were connected with probably the most ambitious cryptographic project ever undertaken by a government—breaking Soviet code during the Cold War. Can you recount some of that?***

This was one project that I was assigned to—very, very deeply—immediately at the start of the Cold War. There was the presumption that the Soviets had become undecipherable, that we would not have enough warning to respond defensively to their threats. We were assigned by President Eisenhower to assess the situation.

So a group of us carried out a very detailed study, and by 1956 we said there are ways of getting at this problem. We said we think we can get to a place where there could be warning and also knowledge of what the Soviets were doing. That did work out thanks to the great skills of the National Security Agency, and the system has been used for American defense very steadily and intensively since about 1957, and it did avoid some nuclear confrontations.

***You mean you developed the means to pick up conversations among Soviet strategists?***

Not only conversations but some of their war plans, the status of their technology, and their command-and-control systems which they had installed outside Moscow, in subterranean form, all in the most extraordinary depth and detail. They either believed or wanted to believe that there was going to be a nuclear war of annihilation and they built a system that was extraordinarily survivable. They believed the U.S. was going to preempt the situation and make the first strike. And we, of course, felt we were the ones facing that threat, along with other numerous aggressions. So they built a very elaborate system, but the National Security Agency broke it. That was a first major software challenge. We did succeed, but we haven't mentioned this capability until recently.

***Was this the Cold War version of Project Ultra, which broke the Nazi code during World War II?***

Well, this came from Ultra but it went way beyond it. We were pretty fragmentary at first. It was a terribly difficult job because the Russians had really pretty good systems. They were so much better than the Japanese and others that it wasn't even funny. The National Security Agency was absolutely central to what we did. [As a result of this work, the intelligence community 10 years ago established in Baker's name a medal and award for outstanding intelligence service.]

***Was the Soviet posture vis-à-vis us defensive? Did they assume all along that we would be making the first strike? The American public was certainly led to believe that a Soviet first strike was a real possibility.***

Well, we don't know, even though we read a lot of their deepest and darkest secrets and actually even intercepted their vehicular traffic. What we do know is they were aggressive in wanting to maintain their proper place in the world. They had to show they were as good as anybody and nobody was going to get in the way of the Soviet Union or communism. They were absolutely brutal about any threat to themselves. They cloaked an awful lot of stuff—the imprisonment of hundreds of people and all the rest of it—in the notion that they were being threatened and were just defending themselves. It is interesting that we never really found that they were going to try to invade the U.S. and govern the country. You might say that's contrary to what they did in Eastern Europe, but the Eastern Europe deal had a large defensive component.

***Your cryptographic system would have told you whether the Soviets were getting ready to launch. How much time did we in the West have between Soviet preparation to launch and actual launch? Would there have been enough time to negotiate in between?***

Of course, we worried about that a great deal, partly because of exercises they had where they didn't actually launch but brought it to the stage where they could launch. We believe the time between preparation and actual launch was 15 to 20 minutes. But that omits the whole command-and-control aspect of preparation. We always insisted that we would have 12 to 24 hours' warning due to one indication or another. When they invaded Czechoslovakia in 1968, we had a couple of days' warning of their military preparation. So the question has a pretty wide spectrum of answers.

***Don't you think the Soviets could see how their paranoia contained the seeds of their own suicide?***

That's reading too much into them. Paranoia is a major element in their whole philosophy. Irrationality is the point. While they might have recognized their weakness, they couldn't avoid it. They cultivated it. And that's what we kept encountering. We had a constant struggle with these people and their special forms, spies, and penetration of all kinds. For example, we had developed techniques to detect bugging and found that they had bugged the embassy we built in Moscow so thoroughly that it was just a network of wires and such stuff. How they thought we wouldn't know that, I don't know. But their defensive position was so pathological that almost anything you could think of they would categorize as something to defend against.

***Were the threats of the Cold War exaggerated, or do you believe it was, in fact, a very dangerous time for the country?***

There's just no doubt that there had to be a Cold War. There's just no doubt that the instability of the Soviet system was such that we would have had nuclear events of one sort or another if we hadn't been ready to respond. I was sitting around the Cabinet room during the Cuban missile crisis of October 1962, and it was one of the most dangerous, grimmest sort of issues you could imagine. We had to face it.

***So you were physically in the White House with President Kennedy at the time of the Cuban missile crisis?***

Yes. I was the legman for various operations during that crisis. We set up the command post in the State Department, which may sound silly, but that was one of Kennedy's wise decisions. Namely, he knew the Defense Department was on trigger edge, and he wasn't going to have anything happen.

What we did was kind of intriguing. The new State Department building had been finished. Its auditorium was completed, but hadn't been used yet as an auditorium. But there it was, a big room that could be carefully secured, and it had some pretty good communications. So Kennedy had us set up a command post there, which we did. We were prepared to go to war if necessary, or inject orders to launch the missiles right from that center.

But it was controlled by the president, and not by the joint chiefs, much to their annoyance. And so I had to run back and forth between the White House and the State Department to keep the executive committee, as they called it, in touch. I remember the morning when the Soviet vessel with these big missiles was steaming right toward Cuba. The plan was that if they passed a certain point on the chart we'd sink them. The president wanted to know if everything was ready.

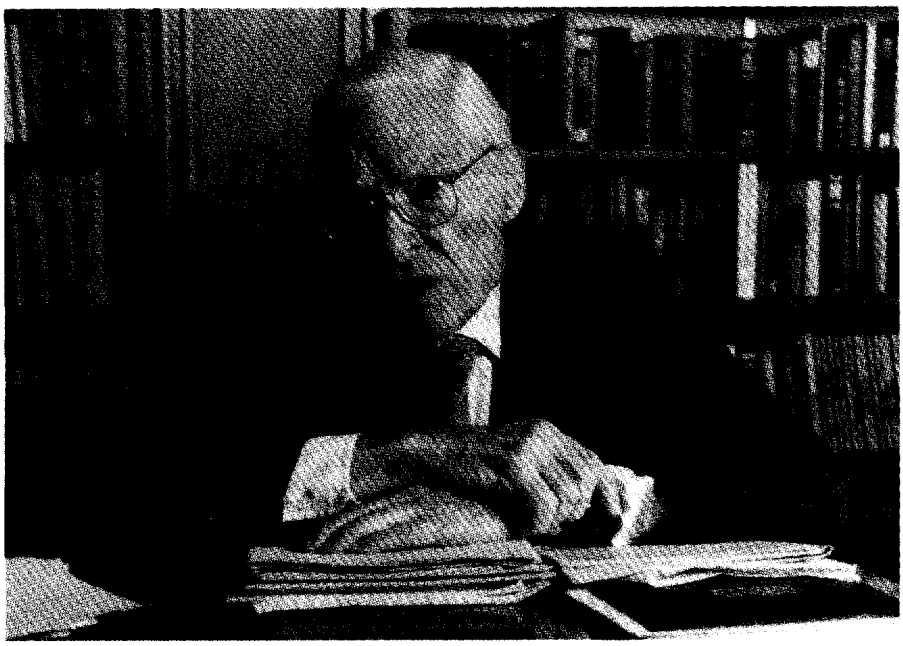
So I went from the White House to the State Department and they said that they were ready to launch torpedoes that would sink that ship. As I started out the State Department entrance, here came Carl Kaysen, assistant to McGeorge Bundy, tearing down on the other side. He had just gotten the report from the National Security Agency saying the ship had turned, and he was shouting, "They turned, they turned!" I'll never forget that. We went back into the State Department and began to demobilize the whole structure.

***How would you compare the Eisenhower and Kennedy presidencies?***

I must say that both those presidents took us into their hearts and they were very, very gracious indeed. Kennedy used to take us into his living quarters for long periods and to meet heads of foreign states. So did Eisenhower. I would say there was remarkable coherence in those two Administrations in that they both had the national interest so strongly in mind and heart that you could find a lot of congeniality between them. Not that they particularly liked each other. They had some doubts about one another, though Kennedy really wasn't very well acquainted

with Eisenhower. But they both had a great sense for calling forth the resources of the country. They went to people in industry and public affairs who really knew something and paid attention to them. So there was an extraordinary coherence about Kennedy and Eisenhower.

So Eisenhower had a remarkable sense of statesmanship. You'd expect Eisenhower to have that because of all of his experience. But Kennedy had it, too. Kennedy's reaction during the Cuban missile crisis—which really was a dreadful affair, we came awfully close to a nuclear event—was that he put the national interest absolutely at the top. Two or three of these congressmen who were heads of the armed services committees said "It's very simple, Mr. President. You can bomb Cuba, you can just level it out and get rid of that business." He just shook his head and said: "I can understand your feelings, Senator so-and-so, but I'm not going to do it. We are responsible to the American people, and we're not going to do it." Kennedy conducted himself with extreme wisdom during that period.



***During these times, weren't you kind of an ex officio science adviser? You had your job at Bell Labs, of course.***

Well, yes, but that Washington work was a by-product of this deeper telecommunications function. I worked for these folks on the basis of intelligence and national security and strategy, and Edwin Land [inventor of the Polaroid camera] did some of that with me. Security was something that was constantly on their minds. Therefore, on the science adviser side, they would turn to us just as Kennedy and later Ford and Nixon did as a matter of convenience. I don't think they were really organizing or categorizing whether this or that was science advice or national security advice. They recognized that telecommunications were intrinsic to it all. And I got fingered a fair amount on that basis.

***We now come to the nature of science advice to the presidency, the role and necessity of a science adviser, and matters relating to that. The office has evolved and devolved over the years. We know that Nixon abolished the office in 1973 and you, with Simon Ramo (then chairman of TRW) were instrumental in reestablishing it. What do you recall of the events during that time?***

I did nominate Ed David as science adviser to Nixon after Lee DuBridge left. We did do some other interesting things while DuBridge was still there, putting civilian and other unofficial elements into the operation of the old Office of Science & Technology. (I had chaired the task force which proposed the conversion of the original White House Science Office into the Office of Science & Technology.) That was how we got into the science advising part of it. And then when Rockefeller joined Ford as his vice president, we had already worked a lot with Rockefeller in our intelligence and strategy plans. So then Ford turned to us for some of his science advice and we recommended Guy Stever, then head of the National Science Foundation.

***Why did Nixon decide to get rid of the science advisory apparatus back in 1973?***

Nixon had keen political sensibilities and was aware that people were ignoring the role of technology, and he felt that because something like technology was lacking, it meant that the science advice was futile and irrelevant to a lot of his concerns.

***One would have thought there was such ferment in science and technology at the time that Nixon might want to have kept a science adviser.***

It's the old story. Both Nixon and Ed David recognized that technology policy was not being formulated effectively and felt that the agencies should be responsible for doing that. So Nixon, who had to deal with the energy crisis resulting from the Yom Kippur War, had these councils and tried to get people to work with their own missions. He thought the issue went far beyond science and wasn't the kind of thing the White House, through any science office, could manage. The president did tell me about abolishing the science adviser post, but I didn't have much to say about it.

***So Ed David and the whole apparatus went. Then along came Ford. Did President Ford in his heart really believe that he needed a science adviser, or did someone whisper it in his ear?***

Oh, I don't think so. He was conscientious. He knew there was a science office, that there was a science adviser, he wanted to be sure he wasn't upsetting the works by ignoring it or by not doing something useful. So he was perfectly agreeable. But George Shultz [then head of the Office of Management & Budget] said "You don't need a science adviser, you can do away with this—the National Science Foundation can function in that way perfectly well." We said that is not such a good idea.

***But you had a concept of the science adviser's role that I think you still have now, that the president doesn't really need one. That is, as an integrator of information, someone at the top who can see emerging problems or the need for an emerging synthesis. If there's no science adviser, who's got that function in government?***

Yes, that's a perfectly good function that every president ought to look for somehow, and many of them won't do that. One reason they don't do that, I think, is that it's fought by all the other members of the staff because the favorite thing there is

to stab somebody else in the back. The struggle for power there is really very, very intense, and so if there's someone who seems to have the president's ear on looking ahead or seeing what things ought to be done, they're going to go after that person just as hard as they can. They're going to isolate him. And this works.

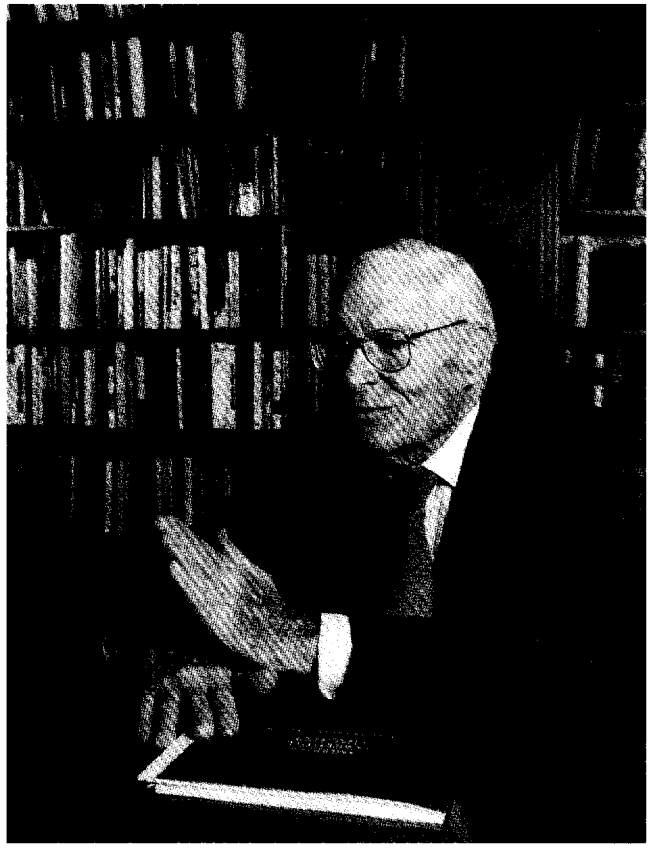
***Why did Jimmy Carter, who defeated Ford in 1976 and who was educated as an engineer, have no use for a science adviser?***

As an engineer he felt he could handle it himself or knew where to turn for it.

***What did you think of President Reagan's Strategic Defense Initiative, or Star Wars? Were you involved in that program?***

Yes, I was to an extent. Star Wars was from our view a most interesting play of public responses, and President Reagan was perfectly sincere about it. He really believed that science and technology could do a great deal in stabilizing and defending our principles. Some people in Cambridge [pro-disarmament scientists associated with Harvard and Massachusetts Institute of Technology] said it was a nonsensical idea and it had to be shown that it was nonsensical. The National Academy of Sciences/National Research Council also stirred things up when it issued a report saying that the software for Star Wars—shooting down a ballistic missile—was beyond human capability. We responded to that at Bell Labs in a contract by saying that this wasn't so. We said there was a capability, but it would require a lot of resources. By the time Reagan's term was finished, I think we were at a stage where a limited defense system safeguard would have worked. This is all carefully documented in our archival books at the labs.

It probably did have the additional effect that Reagan is properly being given credit for, that it probably scared the Soviets enough so that it hastened the disintegration of that system. But we never accepted the notion that we or anybody could succeed in Star Wars the way the president had proposed—an impenetrable shield against Soviet antiballistic missiles.



***What do you think of Clinton's science and technology advisory setup?***

In the absence of a major compelling national focus, which we don't have now, I see no particular function for a science adviser. I think Al Gore finds it's a useful sounding board, and finds the science office a convenient link with his interest in academic affairs. I don't think Clinton has any particular connection with what a science office could do or is needed to do, although the present science adviser [John Gibbons] is most conscientious and well placed.

I may be oversimplifying the whole deal in the sense that maybe these people would claim that they have a much stronger interest or knowledge about sci-

ence than I think. But the evidence is the other way.

***Isn't there some kind of function for an outside science and technology advisory group in the idealized role of presenting to the president major things to think about in a technical realm?***

Yes, I think there's a function all right, if the president was interested in it. But that function, on the one hand, should have a lot of technology in it, which the current President's Council of Advisers on Science & Technology is not very well equipped to do. On the other hand, it should have some kind of focus on what's filling the president's mind. And there's no evidence that anything technical or scientific is actually filling this president's mind.

In the face of that, I really hesitate to say whether there's any function in that office that's significant.

***But we have Office of Science & Technology Policy Director John Gibbons characterizing his office as being involved in everything under the sun and therefore being significant. He functions not so much as a science adviser to a president, but is present at the table whenever science is called on, though it never is quite clear when that is.***

Well, my analogy is a rather crude one, but I see the present role of a science adviser as an ethicist or a reverend who is at all these things. Science advising ought to be built into the institutions rather than have a reverend or someone going to the economic council and saying, be honest, don't defraud anyone, don't deflate the currency, or some such thing.

***But Gibbons might say, "This is the way it's built in." You seem to be saying there is already built into these structures the expertise, or at least the sensitivity to expertise and the means to get it.***

Yes. There's a lot of it in Executive Branch agencies. If you made a point of it and if you really worked at it, I think there would be a lot of it. It would rise and it would become recognized. It's all part of our basic theme today, that science and engineering really are parts of the culture. They really are parts of what makes the nation work. They really are parts of life.

But the science adviser is just a nuisance in a system where the agencies already feel they know everything anyway and, that being the case, they aren't going to pay attention to it at all. The Department of Energy is a classic example

where the science component is a major element of what it does and it's not heeded adequately in policy.

***Let's diverge for a moment to how the Department of Energy's national laboratories should be best put to use.***

These labs would be wonderful opportunities, if someone would take the lead. The issue hasn't really been faced in that they obviously either have to be fully industrially responsible or they have to have some educational function. On the educational side, I can imagine them forming the nucleus of consortia of universities that are multidisciplinary. So the laboratories might be a graceful way of saying you can keep your department structure, and we'll provide you with a place where, if you're smart enough, you can join with some other universities to do something exciting.

It seems this might be a graceful way of overcoming the stagnation from disciplinarity on one hand and the federal entitlement phobia on the other. The universities can get entitlement as their right without feeling controlled, the national interest would be served, and the value would be maintained.

***What do you think about the states taking more of a role in setting and executing national science and technology policy?***

I'm very hot on that subject at the moment. I think the states are the ones to look to for the effective carrying out of policies, and there is more contained creativity there than anywhere else. On the whole, the state governments give an opportunity for flexibility, initiative, and a sort of intimacy between universities and industries that you can't get anymore in Washington.

***Your government work as well as your own curiosity have led you into a number of other areas, such as the environment. How did that come about?***

I have always felt that science and technology should have a broader role in public affairs and in our culture than has been generally assumed. We got interested in that subject before there was an Environmental Protection Agency. It goes back to the time when Lloyd Cooke [former research executive at Union Carbide] and I were worried about chemistry inputs into environmental issues. The American Chemical Society had a Committee on Chemistry & Public Affairs, and it was looking for things that might be of concern. We said this pollution business is going to be of very great concern to the country, except that chemistry people are not doing much about it. So we pulled together the group that produced the report "Cleaning our Environment: The Chemical Basis for Action."

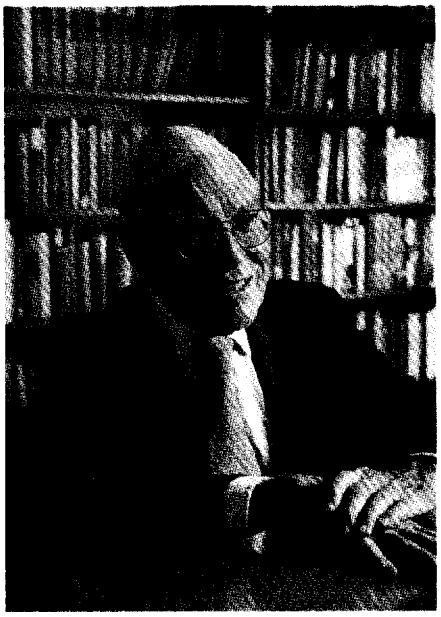
At around the same time, I was asked by the academy to get some idea of what the environmental potential of the automobile business was. I was always interested in the automobile economy anyway and we organized a typical National Academy of Sciences symposium on automobile emissions, and we invited the automobile companies to participate and be the principal leaders. To my horror, they were forced by their legal staffs to refuse. So we had a situation where the American automobile industry was unwilling to report typical carbon monoxide, carbon dioxide emissions to the National Academy of Sciences.

This seemed like a bad sign, and so I became curious and stuck with the subject.

That was three or four years before there was any legislation. The trouble was that when legislation came along it typically got formed on the basis of popular impression rather than on information. Then, Sen. Edmund M. Muskie (D-Maine) was a leader on that and it was to his credit that after he finished his term and after he was in the State Department, he said he wished he had never heard of the subject because he didn't know what he was doing. The figures on nitrogen oxide and carbon dioxide were completely fictional. So that heightened my concern. By the time EPA came along, I was pretty much intrigued by what could be done. EPA enablement of 1970 was not a good piece of legislation, but at least it recognized the problem. Industry got outraged and tried to oppose a lot of it, but it's done them a tremendous amount of good.

***You are now involved in educational reform in New Jersey, as well as in national education reform. What are you seeking to achieve through this work?***

We in Project 2061 [operated by the American Association for the Advancement of Science] are convinced that if you learn science and mathematics at an early age, you become literate in spite of yourself. You can't help it. That's an idea conventional educators are very nervous about, but we are seeing more and more evidence that it's true. We are finding that science and math literacy starts at preschool and nursery school. By age three or four children are showing critical thinking.



***And so what are the implications of that?***

The whole question of learning is open to extraordinary development. Project 2061 has a program called Science for All Americans, which starts out with requiring teachers to understand the arena of science and mathematics—especially mathematics—so well that they will have the three- to four-year-olds involved in thinking. You have to have teachers who are capable of understanding this instead of giving the kids cookbook processes requiring rote learning, and obviously you have to start education at age three or earlier.

Much of this goes back to some work we did at Bell Labs in word and speech recognition, and the logical processes of learning. These processes are accessible to three- and four-year-olds. We're not saying they're not accessible to two-year-olds, but they're not used very much in that age group.

***What level of mathematics are we talking about here?***

There is work, for example, by math professor Lynn A. Steen at St. Olaf's College in Minnesota, on formulated logic system using images that are so exciting that kids grab it. This involves topology-oriented math that doesn't involve rigid formulas at that stage, but it has the very same logic that you use in arithmetic and certain types of geometry. Now, of course, we use the usual workstation resources of the simple computer system as well, and the kids at four, five, or six seem to take to that strongly, too. They will do mathematical functions that the computer illustrates either by figures or by graphs, so there's a new frontier of mathematical learning coming on here.

***Is it of any concern to you whether these developments need to be balanced with social, moral, ethical, and humanistic education that we don't often have in the public schools?***

Humanism in education is so far behind and distant that it's very embarrassing to educational reform. The new standards that the National Academy of Sciences and the Department of Education have both projected this past year are almost word for word the standards in science and math that we did for 2061. This is clearly accepted. They announced it that way. So reform for science and math is all laid out. It has gotten to the stage that state legislatures are adopting these standards generally for kindergarten through grade 12. The standards for the humanities, linguists, and general learning are so complex and difficult, that nobody is doing much. The state legislatures are seeing the disparity between what the kids are being taught and can be taught in the humanities and what is being done in science and math so that they won't act on overall reform.

***One would think the humanities are compatible with at least a theoretical interest in the impact of science and technology on culture.***

The point is that the antiscience movement is so strong now that hardly anyone knows how to bring these together. I don't see that there's really much convergence. I don't know how society is going to resolve this disparity between learning science and math and this so-called humanism, though I think there are perfectly compatible realms there.

***Are you satisfied with the structure of the federal role in precollege education.***

We've tried to find something viable there but haven't found it yet, through several Administrations. Reagan was much interested in this. I don't go as far as Newt Gingrich in saying the Department of Education should be abolished, but with 16,000 school boards to deal with, there's something untenable there. The department's way of getting into that system just doesn't work.

***What do you think about the National Science Foundation's efforts?***

What I and others feel as we dig further into this, is that NSF's State Systemic Initiative—which aims to reform science and math teaching in school systems—has served essentially to dramatize the politics of school systems rather than getting at the actual operations.

***Switching over to your corporate home, how much have the economics and character of Bell Labs changed from the time when you were in charge?***

Well, I think they're not so different. When we served it, of course, we got funds from the combination of Western Electric and AT&T. In other words, they financed the major part of our operation on the same basis as any manufacturing company at the time would have been expected to do—around 10% of sales. There was, however, a modulating factor in that AT&T took a keen interest in the basic science part and helped us on that. Neither one of them, AT&T nor Western Electric, attempted to control or specify our programs, or relate them to specific spending. We submitted annual work plans, of course—which were really quite extensive—and worked in connection with the engineering section of AT&T, which had to do with the operating companies and the actual functions of the network and, of course, the manufacturing needs of Western Electric.

***How important is chemistry now to the work at Bell Labs?***

Oh, very important indeed. But there's a trend there so that chemistry and materials science and engineering are distributed much more widely in manufacturing and design functions and systems integration than ever before. So you won't find quite the sole emphasis, quite the defined areas in chemistry, that we had and benefited from in materials behavior for so many years. The answer is that chemistry is alive and well in many forms—nanochemistry is one. We've tried to introduce the concept of a systems approach to chemistry, but it's taking a long time to get it going. So we have an evolving picture of a strong area at Bell Labs.◀